

[0089] In the present exemplary embodiment, the 2D material layer 53 may serve as a channel layer, and may have, for example, a PNP structure or an NPN structure. The insulating layer 52 may be a gate insulating layer, and the first conductive layer 51 may be a gate electrode. The second and third conductive layers 54 may be a source electrode and a drain electrode, respectively. The second and third conductive layers 54 may be in contact with a P-region of the 2D material layer 53 when the 2D material layer 53 has a PNP structure, and on the other hand, the second and third conductive layers 54 may be in contact with an N-region of the 2D material layer 53 when the 2D material layer 53 has an NPN structure. Meanwhile, when the semiconductor device of FIG. 10 is used as a photodetector, the 2D material layer 53 may be a photoactive layer.

[0090] The above descriptions are only descriptions of certain exemplary embodiments, and should not be construed as limiting the scope of the exemplary embodiments. The scope of the exemplary embodiments should be defined by the claims, and all technical modifications and variations falling within the spirit and scope of the exemplary embodiments should be construed as being included in the scope of the claims. Therefore, it should be clear to those skilled in the art that the above-described descriptions may be implemented with modifications which modify the exemplary embodiments into various forms.

[0091] The current exemplary embodiments can be implemented as computer readable codes in a computer readable record medium. Codes and code segments constituting the computer program can be easily inferred by a skilled computer programmer in the art. The computer readable recording medium includes all types of recordable media in which computer readable data are stored. Examples of the computer readable recording medium include a ROM, a RAM, a CD-ROM, a magnetic tape, a floppy disk, and an optical data storage. Further, the recording medium may be implemented in the form of a carrier wave such as an Internet transmission. In addition, the computer readable recording medium may be distributed to computer systems over a network, in which computer readable codes may be stored and executed in a distributed manner.

[0092] A number of examples have been described above. Nevertheless, it will be understood that various modifications may be made. For example, suitable results may be achieved if the described techniques are performed in a different order and/or if components in a described system, architecture, device, or circuit are combined in a different manner and/or replaced or supplemented by other components or their equivalents. Accordingly, other implementations are within the scope of the following claims.

What is claimed is:

1. A semiconductor device comprising:
  - a substrate;
  - a two-dimensional (2D) material layer formed on the substrate and having a first region and a second region adjacent to the first region; and
  - a source electrode and a drain electrode provided to be respectively in contact with the first region and the second region of the 2D material layer,
 wherein the second region of the 2D material layer includes an oxygen adsorption material layer in which oxygen is adsorbed on a surface of the second region.
2. The semiconductor device of claim 1, wherein a difference between a work function of the oxygen adsorption

material layer and a work function of the 2D material layer in the first region is 0.3 eV or more.

3. The semiconductor device of claim 2, wherein the 2D material layer is formed of MoS<sub>2</sub>.

4. The semiconductor device of claim 3, wherein an oxygen adsorption rate of the oxygen adsorption material layer formed on the surface of the second region of the 2D material layer is 2% or more.

5. The semiconductor device of claim 4, wherein the oxygen adsorption rate of the oxygen adsorption material layer formed on the surface of the second region of the 2D material layer is in a range of 2% to 30%.

6. The semiconductor device of claim 1, wherein the source electrode and the drain electrode are formed of different materials.

7. The semiconductor device of claim 1, wherein one electrode among the source and drain electrodes is formed of Cr or Au and the other electrode among the source and drain electrodes is formed of Pd.

8. The semiconductor device of claim 1, further comprising a passivation layer formed to cover the first region of the 2D material layer.

9. The semiconductor device of claim 8, wherein the passivation layer is formed of an insulating material configured to prevent oxygen from penetrating a surface of the first region.

10. A semiconductor device including a multi-layered structure, the device comprising:

- a semiconductor layer formed of a 2D material and having a first region and a second region, wherein the semiconductor layer includes an oxygen adsorption material layer in which oxygen is adsorbed on a surface of the 2D material in the second region; and
- a non-semiconductor layer provided on a surface of the semiconductor layer.

11. The semiconductor device of claim 10, wherein the semiconductor device is a tunneling device; and the semiconductor layer is a tunneling layer.

12. The semiconductor device of claim 10, wherein the semiconductor device is a binary junction transistor (BJT); and the semiconductor layer is a tunneling layer.

13. The semiconductor device of claim 10, wherein the semiconductor device is a barristor; and the semiconductor layer is a channel layer.

14. The semiconductor device of claim 10, wherein the semiconductor device is a field effect transistor (FET); and the semiconductor layer is a channel layer.

15. The semiconductor device of claim 10, wherein the first region is adjacent to the second region; and the semiconductor device is a diode.

16. A semiconductor device comprising:
 

- a substrate;
- a 2D material layer formed on the substrate and having a first region and a second region adjacent to the first region; and
- a source electrode and a drain electrode provided to be respectively in contact with the first region and the second region of the 2D material layer,

 wherein a first oxygen adsorption rate which is an amount of oxygen adsorbed on a surface of the first region of the 2D material layer is different from a second oxygen

adsorption rate which is an amount of oxygen adsorbed on a surface of the second region of the 2D material layer.

17. The semiconductor device of claim 16, wherein the first oxygen adsorption rate is different from the second oxygen adsorption rate by 0.1 eV or more.

18. The semiconductor device of claim 16, wherein the 2D material layer is formed of MoS<sub>2</sub>.

19. The semiconductor device of claim 16, wherein an oxygen adsorption rate of the oxygen adsorption material layer formed on the surface of the second region of the 2D material layer is 2% or more.

20. The semiconductor device of claim 16, wherein the oxygen adsorption rate of the oxygen adsorption material layer formed on the surface of the second region of the 2D material layer is in a range of 2% to 30%.

21. The semiconductor device of claim 16, wherein the source electrode and the drain electrode are formed of different materials.

22. The semiconductor device of claim 16, wherein one electrode among the source and drain electrodes is formed of Cr or Au and the other electrode among the source and drain electrodes is formed of Pd.

23. The semiconductor device of claim 16, further comprising a passivation layer formed to cover the first region of the 2D material layer.